ORIGINAL ARTICLE

Asian Herpetological Research 2022, 13(4): 205–223
DOI: 10.16373/j.cnki.ahr.220040

Three New Species of *Diploderma* Hallowell, 1861 (Reptilia: Squamata: Agamidae) from the Shaluli Mountains in Western Sichuan, China

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Abstract In recent years, taxonomic research of the genus *Diploderma* has made great progress, but there are still areas lacking relevant investigations. During 2020–2021, we carried out survey of reptile diversity in and around the Shaluli Mountains and collected some specimens of *Diploderma*. Of which, based on systematics inferred from mitochondrial *ND2* gene sequence and morphological data, three new species were recognized: *Diploderma daochengense* **sp. nov.** from the Shuiluo River and Muli River valleys in southeastern Daocheng County, *D. xinlongense* **sp. nov.** from the upper-middle valleys of the Yalong River in Xinlong County, and *D. kangdingense* **sp. nov.** from the Yalong River middle valley and Liqiu River valley. Specifically, these three new species formed three monophyletic lineages with strongly supported and nested into the subclade I of the Bayesian and Maximum Likelihood trees. The uncorrected mean genetic distance between these new species and their closely related species was 4.3% (*D. xinlongense* **sp. nov.** vs. *D. panchi*), 3.4% (*D. daochengense* **sp. nov.** vs. *D. yulongense*) and 5.5% (*D. kangdingense* **sp. nov.** vs. *D. bowoense*), higher than many pairs of species of *Diploderma*. With respect to the morphology, *D. daochengense* **sp. nov.** can be easily diagnosed from *D. yulongense* by having smooth upper edge of the dorsolateral stripes, cyan or dark olive green to yellow gular spots in both sexes and light yellow or white ventrolateral body in males; *D. xinlongense* **sp. nov.** can be easily diagnosed from *D. panchi* by having cyan gular spot in both sexes; *D. kangdingense* **sp. nov.** can be easily diagnosed from *D. bowoense* by having more T4S 20–25 (average 23), more F4S 16–20 (average 17) and yellow to light yellow ventrolateral body, yellow gular spot present in males. To date, the number of species of the genus *Diploderma* has increased to 40, of which 37 species have been known in China.

Keywords Ganzi, taxonomy, Hengduan Mountains, Mountain Dragons, RGB color model

1. Introduction

Species diversity is an important part of biodiversity, and species taxonomy is fundamental to biodiversity researches, further contributing to systematics, biogeography, evolution, ecology and conservation biology (Chiarucci *et al.*, 2011; Jetz *et al.*, 2019). The Mountain Lizard genus *Diploderma* Hallowell, 1861 currently contains 37 described species, and is widely distributed throughout China, Myanmar, Laos, Thailand, Vietnam and Japan (Uetz *et al.*, 2022; Cai *et al.*, 2022; Wang *et al.*, 2022), of which, 34 species are known in China (Wang *et al.*, 2021; Cai *et al.*, 2022; Wang *et al.*, 2022).

The Shaluli Mountains are lied in the eastern part of the Qinghai-Tibet Plateau and in the middle of Hengduan Mountain, and is surrounded by the Jinsha and Yalong Rivers.

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Received: 7 August 2022 Accepted: 16 September 2022

To our knowledge, this mountain range has a high level of biodiversity, to date, just in the genus *Diploderma*, this region is known to harbor 13 species, i.e., *D. panchi*, *D. bowoense*, *D. angustelinea*, *D. panlong*, *D. swild*, *D. dymondi*, *D. flavilabre*, *D. batangense*, *D. formosgulae*, *D. aorun*, *D. qilin*, *D. yulongense* and *D. brevicauda* (Wang *et al.*, 2021; Cai *et al.*, 2022). Most of these species were found near the banks of the Jinsha River, but branches of Jinsha River and the middle, upper and interior regions of Yalong River still lack investigation. So the species diversity in this region might be underestimated.

In 2020 and 2021, we conducted a series of field surveys in and around the Shaluli Mountains, and collected a series of specimens of *Diploderma* species. Based on molecular phylogenetic analyses and morphological comparisions, these specimens contained three undescribed species. Herein, we describe them as three new species.

2. Materials and Methods

2.1. Sampling A total of 28 specimens were collected from in and around the Shaluli Mountains of Sichuan Province, China (Figure 1, Table 1). After taking photographs of these live animals to document their color patterns, they were euthanized by MS-222. Liver tissue samples were taken and preserved

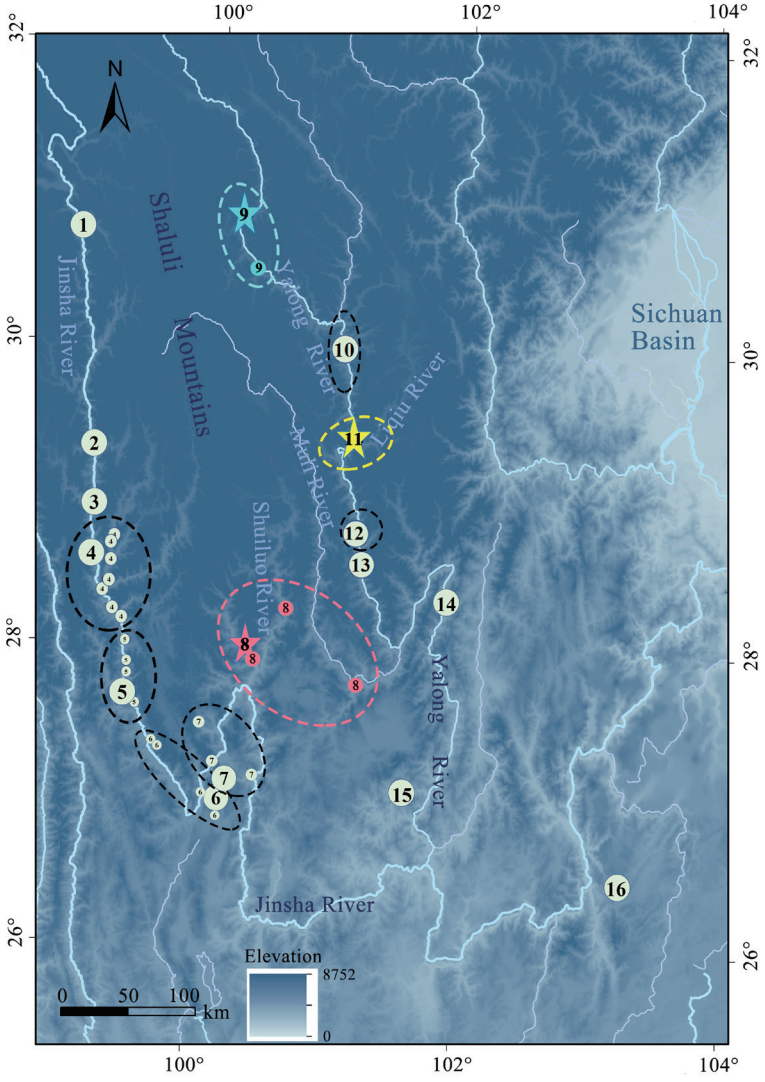

Figure 1 Distributions of *Diploderma* species in and around the Shaluli Mountains. The stars represent the holotype localities of new species described in this paper (8: *D. daochengense* **sp. nov.**, 9: *D. xinlongense* **sp. nov.**, 11: *D. kangdingense* **sp. nov.**); the big circles represent the holotype localities of the remaining recognized congeners (1: D. *flavilabre*; 2: *D. batangense*, 3: *D. formosgulae*, 4: *D. aorun*, 5: *D. qilin*, 6: *D. brevicauda*, 7: *D. yulongense*, 10: *D. panchi*, 12: *D. bowoense*, 13: *D. angustelinea*, 14: *D. panlong*, 15: *D. swild*, 16: *D. dymondi*); the small circles represent the known localities of new species, their sister species and morphologically similar species; and the dotted oval line represents the approximate known range of that species.

Table 1 Samples used in the molecular study with new species indicated in bold and arranged in top-down order within a species.

NO.	Species	Voucher	Locality	*ND2* GenBank Accession Number	References
1	*D. xinlongense* **sp. nov.**	20210907	Wuya, Xinlong, Sichuan, China	OP595613	This study
2	*D. xinlongense* **sp. nov.**	20210908	Wuya, Xinlong, Sichuan, China	OP595614	This study
3	*D. xinlongense* **sp. nov.**	20210912	Wuya, Xinlong, Sichuan, China	OP595615	This study
4	*D. xinlongense* **sp. nov.**	20210906	Wuya, Xinlong, Sichuan, China	OP595616	This study
5	*D. xinlongense* **sp. nov.**	20210911	Junba Bridge, Xinlong, Sichuan, China	OP595617	This study
6	*D. xinlongense* **sp. nov.**	20210909	Junba Bridge, Xinlong, Sichuan, China	OP595618	This study
7	*D. xinlongense* **sp. nov.**	20210910	Junba Bridge, Xinlong, Sichuan, China	OP595619	This study
8	*D. daochengense* **sp. nov.**	20210905	Eya, Muli, Sichuan, China	OP595620	This study
9	*D. daochengense* **sp. nov.**	DC001	Eyatong, Daocheng, Sichuan, China	OP595621	This study
10	*D. daochengense* **sp. nov.**	DC003	Eyatong, Daocheng, Sichuan, China	OP595622	This study
11	*D. daochengense* **sp. nov.**	DC004	Eyatong, Daocheng, Sichuan, China	OP595623	This study
12	*D. daochengense* **sp. nov.**	20210904	Eya, Muli, Sichuan, China	OP595624	This study
13	*D. daochengense* **sp. nov.**	2019ML0037	Xiamaidi, Muli, Sichuan, China	MT753055	Shu *et al.*, 2021
14	*D. daochengense* **sp. nov.**	2019ML0038	Xiamaidi, Muli, Sichuan, China	MT753056	Shu *et al.*, 2021
15	*D. daochengense* **sp. nov.**	Z11	Near Xiamaidi, Muli, Sichuan, China	MT753057	/
16	*D. daochengense* **sp. nov.**	Z16	Shuiluo River, Muli, Sichuan, China	MT753058	/
17	*D. daochengense* **sp. nov.**	Z17	Shuiluo River, Muli, Sichuan, China	MT753059	/
18	*D. kangdingense* **sp. nov.**	20210916	Pusharong, Kangding, Sichuan, China	OP595625	This study
19	*D. kangdingense* **sp. nov.**	20210917	Pusharong, Kangding, Sichuan, China	OP595626	This study
20	*D. kangdingense* **sp. nov.**	KD2021080103	Pusharong, Kangding, Sichuan, China	OP595627	This study
21	*D. kangdingense* **sp. nov.**	KD2021080104	Pusharong, Kangding, Sichuan, China	OP595628	This study
22	*D. kangdingense* **sp. nov.**	KD2021080105	Pusharong, Kangding, Sichuan, China	OP595629	This study
23	*D. kangdingense* **sp. nov.**	KD2021080102	Pusharong, Kangding, Sichuan, China	OP595630	This study
24	*D. kangdingense* **sp. nov.**	20210913	Bosihe, Kangding, Sichuan, China	OP595631	This study
25	*D. kangdingense* **sp. nov.**	20210915	Bosihe, Kangding, Sichuan, China	OP595632	This study
26	*D. kangdingense* **sp. nov.**	20210914	Bosihe, Kangding, Sichuan, China	OP595633	This study
27	*D. angustelinea*	KIZ032491	Muli, Sichuan, China	MT577929	Wang *et al.*, 2020
28	*D. angustelinea*	KIZ032490	Muli, Sichuan, China	MT577928	Wang *et al.*, 2020
29	*D. angustelinea*	KIZ032488	Muli, Sichuan, China	MT577925	Wang *et al.*, 2020
30	*D. angustelinea*	KIZ029705	Muli, Sichuan, China	MT577924	Wang *et al.*, 2020
31	*D. angustelinea*	KIZ029708	Muli, Sichuan, China	MT577931	Wang *et al.*, 2020
32	*D. angustelinea*	KIZ029704	Muli, Sichuan, China	MT577930	Wang *et al.*, 2020
33	*D. angustelinea*	KIZ032489	Muli, Sichuan, China	MT577926	Wang *et al.*, 2020
34	*D. angustelinea*	KIZ029710	Muli, Sichuan, China	MT577927	Wang *et al.*, 2020
35	*D. aorun*	KIZ032737	Benzilan, Yunnan, China	MT577940	Wang *et al.*, 2020
36	*D. aorun*	KIZ032734	Benzilan, Yunnan, China	MT577939	Wang *et al.*, 2020
37	*D. aorun*	KIZ032733	Benzilan, Yunnan, China	MT577938	Wang *et al.*, 2020
38	*D. aorun*	KIZ032735	Benzilan, Yunnan, China	MT577937	Wang *et al.*, 2020
39	*D. aorun*	KIZ032736	Benzilan, Yunnan, China	MT577936	Wang *et al.*, 2020
40	*D. batangense*	KIZ019281	Batang, Sichuan, China	MT577934	Wang *et al.*, 2020
41	*D. batangense*	KIZ019278	Zhubalong, Mangkang, Tibet, China	MT577932	Wang *et al.*, 2020
42	*D. batangense*	KIZ019279	Zhubalong, Mangkang, Tibet, China	MT577933	Wang *et al.*, 2020
43	*D. batangense*	KIZ19314	Zhubalong, Mangkang, Tibet, China	MT577935	Wang *et al.*, 2020
44	*D. batangense*	KIZ019276	Batang, Sichuan, China	MK001413	Wang *et al.*, 2019a

Continued Table 1

NO.	Species	Voucher	Locality	*ND2* GenBank Accession Number	References
45	*D. batangense*	KIZ019277	Batang, Sichuan, China	MW133359	Che *et al.*, 2021
46	*D. batangense*	KIZ09404	Zhubalong, Mangkang, Tibet, China	MK001412	Wang *et al.*, 2019a
47	*D. batangense*	H61	Zhubalong, Mangkang, Tibet, China	MT753053	/
48	*D. batangense*	H60	Zhubalong, Mangkang, Tibet, China	MT753052	/
49	*D. batangense*	H62	Zhubalong, Mangkang, Tibet, China	MT753054	/
50	*D. batangense*	H59	Zhubalong, Mangkang, Tibet, China	MT753051	/
51	*D. bowoense*	KIZ044757	Muli, Sichuan, China	MW506020	Wang *et al.*, 2021
52	*D. bowoense*	KIZ044758	Muli, Sichuan, China	MW506019	Wang *et al.*, 2021
53	*D. brevicauda*	KIZ044305	Lijiang, Yunnan, China	MW506021	Wang *et al.*, 2021
54	*D. brevicauda*	KIZ044306	Lijiang, Yunnan, China	MW506022	Wang *et al.*, 2021
55	*D. brevicauda*	KIZ044304	Lijiang, Yunnan, China	MW506023	Wang *et al.*, 2021
56	*D. brevipes*	NMNS19608	Taiwan, China	MK001430	Wang *et al.*, 2019a
57	*D. brevipes*	NMNS19607	Taiwan, China	MK001429	Wang *et al.*, 2019a
58	*D. chapaense*	KIZ034921	Lüchun, Honghe, Yunnan, China	MG214264	Wang *et al.*, 2018
59	*D. chapaense*	KIZ034923	Lüchun, Honghe, Yunnan, China	MG214263	Wang *et al.*, 2018
60	*D. chapaense*	ZMMU NAP-01911	Chapa, Vietnam	MG214262	Wang *et al.*, 2018
61	*D. chapaense*	ROM37961	Sa Pa, Lao Cai, Vietnam	MW133367	Che *et al.*, 2021
62	*D. chapaense*	KIZ046954	Jingdong, Yunnan, China	MK578660	Wang *et al.*, 2019b
63	*D. chapaense*	KIZ046970	Jingdong, Yunnan, China	MK578659	Wang *et al.*, 2019b
64	*D. chapaense*	KIZ047085	Jingdong, Yunnan, China	MK578661	Wang *et al.*, 2019b
65	*D. chapaense*	KIZ040145	Dali, Yunnan, China	MK578667	Wang *et al.*, 2019b
66	*D. drukdaypo*	KIZ027630	Zhuka, Changdu, Tibet, China	MT577954	Wang *et al.*, 2020
67	*D. drukdaypo*	KIZ027628	Zhuka, Changdu, Tibet, China	MT577952	Wang *et al.*, 2020
68	*D. drukdaypo*	KIZ027629	Zhuka, Changdu, Tibet, China	MT577953	Wang *et al.*, 2020
69	*D. drukdaypo*	KIZ016486	Changdu, Tibet, China	MT577951	Wang *et al.*, 2020
70	*D. drukdaypo*	KIZ027627	Jinduo, Changdu, Tibet, China	MT577950	Wang *et al.*, 2020
71	*D. dymondi*	KIZ040149	Panzhihua, Sichuan, China	MT577901	Wang *et al.*, 2020
72	*D. dymondi*	KIZ040148	Panzhihua, Sichuan, China	MT577900	Wang *et al.*, 2020
73	*D. dymondi*	KIZ040147	Panzhihua, Sichuan, China	MT577899	Wang *et al.*, 2020
74	*D. dymondi*	KIZ040640	Dongchuan, Yunnan, China	MK001423	Wang *et al.*, 2019a
75	*D. dymondi*	KIZ040639	Dongchuan, Yunnan, China	MK001422	Wang *et al.*, 2019a
76	*D. flaviceps*	KIZ019579	Kangding, Sichuan, China	MT577898	Wang *et al.*, 2020
77	*D. flaviceps*	KIZ019576	Kangding, Sichuan, China	MT577897	Wang *et al.*, 2020
78	*D. flaviceps*	KIZ019575	Kangding, Sichuan, China	MT577896	Wang *et al.*, 2020
79	*D. flaviceps*	KIZ019577	Kangding, Sichuan, China	MT577895	Wang *et al.*, 2020
80	*D. flaviceps*	KIZ01851	Luding, Sichuan, China	MK001416	Wang *et al.*, 2019a
81	*D. flaviceps*	KIZ019578	Kangding, Sichuan, China	MT577894	Wang *et al.*, 2020
82	*D. flaviceps*	KIZ01852	Luding, Sichuan, China	MK001417	Wang *et al.*, 2019a
83	*D. flaviceps*	DB130601	Danba, Sichuan, China	KX881372	Liu *et al.*, 2019
84	*D. flaviceps*	DB130601	/	NC_039541	Liu *et al.*, 2019
85	*D. flaviceps*	KIZ05182	Luding, Sichuan, China	MW133372	Che *et al.*, 2021
86	*D. flavilabre*	KIZ032695	Baiyu, Sichuan, China	MT577918	Wang *et al.*, 2020
87	*D. flavilabre*	KIZ032694	Baiyu, Sichuan, China	MT577917	Wang *et al.*, 2020
88	*D. flavilabre*	KIZ032692	Baiyu, Sichuan, China	MT577916	Wang *et al.*, 2020

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NO.	Species	Voucher	Locality	*ND2* GenBank Accession Number	References
89	*D. flavilabre*	KIZ032698	Baiyu, Sichuan, China	MT577920	Wang *et al.*, 2020
90	*D. flavilabre*	KIZ032697	Baiyu, Sichuan, China	MT577915	Wang *et al.*, 2020
91	*D. flavilabre*	KIZ032696	Baiyu, Sichuan, China	MT577919	Wang *et al.*, 2020
92	*D. formosgulae*	KIZ044375	Deqin, Yunnan, China	MW506026	Wang *et al.*, 2021
93	*D. formosgulae*	KIZ044420	Deqin, Yunnan, China	MW506024	Wang *et al.*, 2021
94	*D. formosgulae*	KIZ044421	Deqin, Yunnan, China	MW506025	Wang *et al.*, 2021
95	*D. formosgulae*	KIZ044373	Deqin, Yunnan, China	MW506028	Wang *et al.*, 2021
96	*D. formosgulae*	KIZ044376	Deqin, Yunnan, China	MW506027	Wang *et al.*, 2021
97	*D. iadinum*	KIZ027702	Yunling, Deqin, Yunnan, China	MT577957	Wang *et al.*, 2020
98	*D. iadinum*	KIZ027697	Yunling, Deqin, Yunnan, China	MT577956	Wang *et al.*, 2020
99	*D. iadinum*	KIZ027706	Yunling, Deqin, Yunnan, China	MT577955	Wang *et al.*, 2020
100	*D. iadinum*	KIZ019327	Deqin, Yunnan, China	MW133366	Che *et al.*, 2021
101	*D. iadinum*	KIZ019328	Deqin, Yunnan, China	MW111458	Xu *et al.*, 2021
102	*D. laeviventre*	KIZ027691	Basu, Mangkang, Tibet, China	MT577892	Wang *et al.*, 2020
103	*D. laeviventre*	KIZ014037	Basu, Mangkang, Tibet, China	MK001407	Wang *et al.*, 2019a
104	*D. laeviventre*	KIZ027692	Basu, Mangkang, Tibet, China	MT577893	Wang *et al.*, 2020
105	*D. luei*	NMNS19605	Taiwan, China	MK001434	Wang *et al.*, 2019a
106	*D. luei*	NMNS19604	Taiwan, China	MK001433	Wang *et al.*, 2019a
107	*D. makii*	NMNS19610	Taiwan, China	MK001432	Wang *et al.*, 2019a
108	*D. makii*	NMNS19609	Taiwan, China	MK001431	Wang *et al.*, 2019a
109	*D. menghaiense*	L0033	Menghai, Yunnan, China	MT598658	Liu *et al.*, 2020
110	*D. menghaiense*	L0031	Menghai, Yunnan, China	MT598656	Liu *et al.*, 2020
111	*D. menghaiense*	L0030	Menghai, Yunnan, China	MT598655	Liu *et al.*, 2020
112	*D. menghaiense*	L0032	Menghai, Yunnan, China	MT598657	Liu *et al.*, 2020
113	*D. micangshanense*	KIZ023232	Nanyang, Henan, China	MW133371	Che *et al.*, 2021
114	*D. micangshanense*	KIZ023231	Nanyang, Henan, China	MW133369	Che *et al.*, 2021
115	*D. micangshanense*	KIZ023231	Xixia, Henan, China	MK578664	Wang *et al.*, 2019b
116	*D. micangshanense*	/	/	NC_056342	Li *et al.*, 2021
117	*D. micangshanense*	HNUSTM20200824	Luoning, Henan, China	MW242820	Li *et al.*, 2021
118	*D. micangshanense*	KIZ032802	Shiyan, Hubei, China	MK578666	Wang *et al.*, 2019b
119	*D. micangshanense*	KIZ032801	Shiyan, Hubei, China	MK578665	Wang *et al.*, 2019b
120	*D. micangshanense*	WK-JK038	Wenxian, Gansu, China	MK578663	Wang *et al.*, 2019b
121	*D. micangshanense*	WK-JK037	Wenxian, Gansu, China	MK578662	Wang *et al.*, 2019b
122	*D. micangshanense*	KIZ06850	Longnan, Gansu, China	MK001424	Wang *et al.*, 2019a
123	*D. panchi*	KIZ032717	Yajiang, Sichuan, China	MT577947	Wang *et al.*, 2020
124	*D. panchi*	KIZ032715	Yajiang, Sichuan, China	MT577946	Wang *et al.*, 2020
125	*D. panchi*	KIZ032729	Yajiang, Sichuan, China	MT577945	Wang *et al.*, 2020
126	*D. panchi*	KIZ032716	Yajiang, Sichuan, China	MT577944	Wang *et al.*, 2020
127	*D. panlong*	KIZ040141	Miansha, Liangshan, Sichuan, China	MT577909	Wang *et al.*, 2020
128	*D. panlong*	KIZ040139	Miansha, Liangshan, Sichuan, China	MT577908	Wang *et al.*, 2020
129	*D. panlong*	KIZ040138	Miansha, Liangshan, Sichuan, China	MT577907	Wang *et al.*, 2020
130	*D. panlong*	KIZ040140	Miansha, Liangshan, Sichuan, China	MT577905	Wang *et al.*, 2020
131	*D. panlong*	KIZ040137	Miansha, Liangshan, Sichuan, China	MT577906	Wang *et al.*, 2020
132	*D. panlong*	KIZ040143	Miansha, Liangshan, Sichuan, China	MT577904	Wang *et al.*, 2020

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NO.	Species	Voucher	Locality	*ND2* GenBank Accession Number	References
133	*D. polygonatum*	NMNS19599	Taiwan, China	MK001428	Wang *et al.*, 2019a
134	*D. polygonatum*	NMNS19598	Taiwan, China	MK001427	Wang *et al.*, 2019a
135	*D. qilin*	KIZ028335	Balong, Deqin, Yunnan, China	MT577943	Wang *et al.*, 2020
136	*D. qilin*	KIZ028333	Balong, Deqin, Yunnan, China	MT577942	Wang *et al.*, 2020
137	*D. qilin*	KIZ028332	Balong, Deqin, Yunnan, China	MT577941	Wang *et al.*, 2020
138	*D. slowinskii*	KIZ027544	Fugong, Gongshan, Yunnan, China	MT577911	Wang *et al.*, 2020
139	*D. slowinskii*	KIZ027543	Fugong, Gongshan, Yunnan, China	MT577910	Wang *et al.*, 2020
140	*D. slowinskii*	CAS214906	Gongshan, Yunnan, China	MK001405	Wang *et al.*, 2019a
141	*D. slowinskii*	CAS214954	Gongshan, Yunnan, China	MK001406	Wang *et al.*, 2019a
142	*D. slowinskii*	KIZ027573	Qiunatong, Gongshan, Yunnan, China	MT577913	Wang *et al.*, 2020
143	*D. slowinskii*	KIZ027572	Qiunatong, Gongshan, Yunnan, China	MT577912	Wang *et al.*, 2020
144	*D. splendidum*	KIZ017330	Haixi, Qinghai, China	MW133370	Che *et al.*, 2021
145	*D. splendidum*	LSUMZ81212	/	AF288230	McGuire and Heang 2001
146	*D. splendidum*	KIZ015973	Yichang, Hubei, China	MK001418	Wang *et al.*, 2019a
147	*D. splendidum*	/	Pet market, Yunnan, China	MK940807	Huang *et al.*, 2019
148	*D. splendidum*	CAS194476	Yaan, Sichuan, China	AF128501	Macey *et al.*, 2000
149	*D. swild*	KIZ034915	Panzhihua, Sichuan, China	MN266301	Wang *et al.*, 2019c
150	*D. swild*	KIZ034914	Panzhihua, Sichuan, China	MN266299	Wang *et al.*, 2019c
151	*D. swild*	KIZ034894	Panzhihua, Sichuan, China	MN266300	Wang *et al.*, 2019c
152	*D. swild*	KIZ034895	Panzhihua, Sichuan, China	MN266298	Wang *et al.*, 2019c
153	*D. swild*	KIZ034893	Panzhihua, Sichuan, China	MN266297	Wang *et al.*, 2019c
154	*D. swinhonis*	NMNS19593	Taiwan, China	MK001420	Wang *et al.*, 2019a
155	*D. swinhonis*	NMNS19592	Taiwan, China	MK001419	Wang *et al.*, 2019a
156	*D. varcoae*	WK-JK011	Dali, Yunnan, China	MT577903	Wang *et al.*, 2020
157	*D. varcoae*	KIZ026132	Mengzi, Honghe, Yunnan, China	MK001421	Wang *et al.*, 2019a
158	*D. varcoae*	KIZ020412	Mengzi, Honghe, Yunnan, China	MW133368	Che *et al.*, 2021
159	*D. varcoae*	KIZ04289	Kunming, Yunnan, China	MW111459	Xu *et al.*, 2021
160	*D. varcoae*	KIZ029711	Dali, Yunnan, China	MT577902	Wang *et al.*, 2020
161	*D. vela*	CIB5421290081	Quzika, Mangkang, Tibet, China	MW788326	Wu *et al.*, 2021
162	*D. vela*	KIZ034925	Quzika, Mangkang, Tibet, China	MK001415	Wang *et al.*, 2019a
163	*D. vela*	KIZ027672	Tongsha, Mangkang, Tibet, China	MT577949	Wang *et al.*, 2020
164	*D. vela*	KIZ027673	Tongsha, Mangkang, Tibet, China	MT577948	Wang *et al.*, 2020
165	*D. vela*	KIZ019298	Changdu, Tibet, China	MW133360	Che *et al.*, 2021
166	*D. vela*	KIZ019299	Quzika, Mangkang, Tibet, China	MK001414	Wang *et al.*, 2019a
167	*D. yangi*	SWFU005412	Zayu, Tibet, China	OL449604	Wang *et al.*, 2022
168	*D. yangi*	SWFU005414	Zayu, Tibet, China	OL449605	Wang *et al.*, 2022
169	*D. yangi*	SWFU005411	Zayu, Tibet, China	OL449606	Wang *et al.*, 2022
170	*D. yangi*	SWFU005410	Zayu, Tibet, China	OL449603	Wang *et al.*, 2022
171	*D. yulongense*	KIZ028292	Shangri-La, Yunnan, China	MT577922	Wang *et al.*, 2020
172	*D. yulongense*	KIZ43196	Shangri-La, Yunnan, China	MK001411	Wang *et al.*, 2019a
173	*D. yulongense*	KIZ028291	Shangri-La, Yunnan, China	MT577921	Wang *et al.*, 2020
174	*D. yulongense*	KIZ028300	Shangri-La, Yunnan, China	MT577923	Wang *et al.*, 2020
175	*D. yulongense*	KIZ09399	Shangri-La, Yunnan, China	MK001410	Wang *et al.*, 2019a
176	*D. yunnanense*	CAS242183	Baoshan, Yunnan, China	MK001409	Wang *et al.*, 2019a

Continued Table 1

NO.	Species	Voucher	Locality	*ND2* GenBank Accession Number	References
177	*D. yunnanense*	CAS242271	Baoshan, Yunnan, China	MK001408	Wang *et al.*, 2019a
178	*D. yunnanense*	CAS242271	Baoshan, Yunnan, China	MG214260	Wang *et al.*, 2018
179	*D. yunnanense*	CAS242183	Baoshan, Yunnan, China	MG214261	Wang *et al.*, 2018
180	*D. yunnanense*	KIZ040193	Yingjiang, Yunnan, China	MT577914	Wang *et al.*, 2020
181	*D. yunnanense*	KIZ040193	Yingjiang, Yunnan, China	MK578658	Wang *et al.*, 2019b
182	*D. zhaoermii*	KIZ019565	Wenchuan, Sichuan, China	MK001426	Wang *et al.*, 2019a
183	*D. zhaoermii*	KIZ019564	Wenchuan, Sichuan, China	MK001425	Wang *et al.*, 2019a
184	*D. zhaoermii*	MVZ 216622	Wenchuan, Sichuan, China	AF128500	Macey *et al.*, 1997
185	*Acanthosaura lepidogaster*	MVZ 224090	Vinh Phuc, Vietnam	AF128499	Macey *et al.*, 2000
186	*Calotes versicolor*	CIB091468	Hainan, China	KC875820	Huang *et al.*, 2013
187	*Pseudocalotes kakhiensis*	KIZ015975	Gongshan, Yunnan, China	MK001435	Wang *et al.*, 2019a

Note: The missing data are marked as "/".

in 95% ethanol for molecular analyses. Other tissue samples were stored in 99% ethanol and specimens were preserved in 75% ethanol. All specimens were deposited at the Museum of Herpetology, Chengdu Institute of Biology (CIB), Chinese Academy of Sciences (CAS). Field collection of specimens was authorized by the Forestry and Grassland Bureau of Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China. The animal care and use protocols have been reviewed and approved by Animal Ethical and Welfare Committee of Chengdu Institute of Biology, CAS (Number: 2017-AR-JJP-03).

2.2. DNA extraction and sequences of *ND2* Total genomic DNA was extracted from the liver tissue of every specimen collected in this study using the QIAamp DNA Mini Kit (QIAGEN, Hilden, Germany) following the manufacturer's recommended protocols. The mitochondrial gene NADH dehydrogenase subunit 2 (*ND2*) was amplified and sequenced. The primer sequences (Jap_70F: CCACCAAACAACTA CACCTA, Jap_1559R: GGATTAATGCCCTCTGGATT) were retrieved from Wang *et al.* (2019). The PCR amplifications were performed in a 30 μL reaction volume with the following conditions: an initial denaturing step at 95 °C for 4 min; 36 cycles of denaturing at 95 °C for 40 s, annealing at 55 °C and extending at 55°C for 70 s, and a final extension step of 72 °C for 10 min. PCR products were sequenced with both forward and reverse primers as used in PCR. Sequencing was conducted using an ABI3730 automated DNA sequencer at Sangon Biotechnologies Co., Ltd. (Shanghai, China). New sequences were uploaded to GenBank (see Table 1).

2.3. Molecular phylogenetic analyses There were 21 novel sequences of *ND2* obtained in this work, and a total of 163 *ND2* sequences of 33 *Diploderma* species were downloaded from GenBank for phylogenetic analyses (Table 1). In addition, corresponding sequences of *Acanthosaura lepidogaster* (AF128499), *Calotes versicolor* (KC875820) and *Pseudocalotes kakhienensis* (MK001435) were downloaded and used as outgroups according to Wang *et al.* (2022).

Sequences were assembled and aligned using BioEdit v. 7.0.9.0 (Hall 1999) with default settings and were further revised manually if necessary. Non-sequenced fragments were treated as missing data. Phylogenetic analyses were conducted using Bayesian inference (BI) and maximum likelihood (ML) methods implemented in MrBayes v. 3.2 (Ronquist *et al.*, 2012) and PhyML v. 3.0 (Guindon *et al.*, 2010), respectively. Before the phylogenetic analyses, the best evolutionary model was conducted and chosen under the Bayesian inference criteria (BIC) using jModelTest v. 2.1.3 (Darriba *et al.*, 2012). The analyses selected the GTR + F +I+G4 model for the mitochondrial gene. In the BI analyses, the parameters for each partition were unlinked, and branch lengths were allowed to vary proportionately across partitions. Two runs each with four Markov chains were simultaneously run for 80 million generations with sampling every 1000 generations. The first 25% of trees were removed as the "burn-in" stage, which was followed by calculations of Bayesian posterior probabilities at stationarity, and the 50% majority-rule consensus of the postburn-in trees sampled was obtained. For the ML tree, branch supports were drawn from 10000 nonparametric bootstrap replicates. Finally, uncorrected genetic pairwise distances (p-distances) were obtained for the coding region of *ND2* using MEGA 6.0. (Tamura *et al.*, 2013).

2.4. Morphological analyses Measurements were taken mainly following Zhao *et al.* (1999) to the nearest 1 mm using a steel ruler for snout-vent length (SVL) and tail length (TAL), and to nearest 0.1 mm using a digital calliper for other

relatively short measurements. Totally, seven measurements were measured, snout-vent length (SVL): distance from the snout tip to anterior edge of the vent; tail length (TAL): distance from the anterior edge of the vent to the tip of tail; head length (HL): distance from the tip of snout to the right angle of the jaw; snout-eye length (SEL): distance from the tip of snout to the anterior margin of the eye; foreleg length (FLL): distance from the armpit to the tip of finger IV, excluding the claw, measured as the limb straightened; hindleg length (HLL): distance from the groin to the tip of toe IV, excluding the claw, measured with the limb straightened; trunk length (TRL): distance from the armpit to the groin.

Definitions of morphological characters and the counting methods also mainly followed Zhao *et al.* (1999) and Wang *et al.* (2021) as follows, supralabial scale count (SL): number of enlarged, modified labial scales from rostral to the corner of the mouth; infralabial scale count (IL): number of enlarged, modified labial scales from mental to the corner of the mouth; suborbital scale rows (SOR): number of longitudinal rows of scales between supralabials and inferior-most edge of orbit circle, excluding fine ciliary scales in the orbit; middorsal crest scale count (MD): number of modified crest scales longitudinally from the first nuchal crest to the scale above the cloaca; finger IV subdigital lamellae count (F4S): number of subdigital lamellae scale from the base between finger III and IV to the tip of finger IV, excluding the claw; toe IV subdigital lamellae count (T4S): number of subdigital lamellae scales from the base between toe III and IV to the tip of toe IV, excluding the claw; radial stripes below eyes (RSBE): absent or present; gular fold state (GF): absent or present; gulat pouch state (GP): absent or present; gular spot state (GS): absent or present; gular spot color (GSC); tympanum state (TS): absent or present; skin fold under nuchal crest (SFNC): absent or present; nuchal crest state (NC): crest scale strongly erected or not; skin fold under dorsal crest (SFDC): absent or present; shape of dorsolateral stripes (SDS): defined as the shape of dorsolateral stripe in males, either smooth edged or jagged; ventral scale state (VSS): absent or present; hindlimbs adpressed forward (HAF): the hindlimbs adpressed forward to reaching the area.

Coloration descriptions were using terminology and codes in RGB (red, green, blue) color model, which is widely used in various fields (Ibraheem *et al.*, 2012). Data of coloration and ornamentation were also collected from life specimens both in low light or stressed state, including the following (Wang *et al.*, 2021): inner-lip coloration (ILC); coloration of the oral cavity (CO): defined as the background coloration of the anterior roof and sides of the mouth, excluding the posterior palate and deep throat; coloration of the tongue (CTG): defined as the coloration of the tongue; coloration of the dorsolateral stripes (CDS): defined as the background coloration of the dorsolateral stripes; ventrolateral body coloration (VLBC); spots coloration of ventrolateral body (SCVB); suborbital scale color (SOC): color of scales between supralabials and inferior-most edge of orbit circle, excluding fine ciliary scales in the orbit; coloration of the supralabial (CSL) and ventral body coloration (VBC).

3. Results

3.1. Molecular phylogenetic analyses The final alignment contain 1032 bp of *ND2*, and two consistent topologies of phylogenetic trees are obtained from BI and ML analyses, showing that all analyzed species of *Diploderma* are strongly clustered into one monophyletic clade, and further five subclades are recognized (Figure 2).

The newly collected samples from the Shuiluo River and Muli River valleys population, the upper-middle valleys of the Yalong River population, and the Yalong River middle valley and Liqiu River valley population are clustered into three distinct lineages, respectively, and are well supported. Specifically, the Shuiluo River and Muli River valleys population is sister to *D. yulongense*, the upper-middle valleys of the Yalong River population is sister to *D. panchi*, and the Yalong River middle valley and Liqiu River valley population is sister to *D. bowoense*.

Because all the three newly recognized lineages belong to the subclade I, genetic distance is just calculated among those species within this subclade. The uncorrected mean genetic distance range is 2.5%–19.6%, while the genetic distance between the upper-middle valleys of the Yalong River population and other congeners is at least 4.3% (the upper-middle valleys of the Yalong River population versus *D. panchi*), that between the Shuiluo River and Muli River valleys population and other congeners is at least 3.4% (the Shuiluo River and Muli River valleys population versus *D. yulongense*), and that between the Yalong River middle valley and Liqiu River valley population and other congeners is at least 5.5% (the Yalong River middle valley and Liqiu River valley population versus *D. bowoense*), which are much higher than the shortest genetic distance of *Diploderma* species (2.5% between *D. vela* and *D. drukdaypo* (Table 2).

Moreover, the uncorrected mean genetic distance among samples of the upper-middle valleys of the Yalong River population is 1.4% (range from 1.1% to 1.7%), that among the Shuiluo River and Muli River valleys population samples is approximately 0.5% (range from 0.3%–0.7%), and that among the Yalong River middle valley and Liqiu River valley population is 0.4% (range from 0.2% to 0.6%).

The results of molecular phylogenetic analyses above indicate that the genetic differentiations among the three lineages newly recognized in this work and others have reach

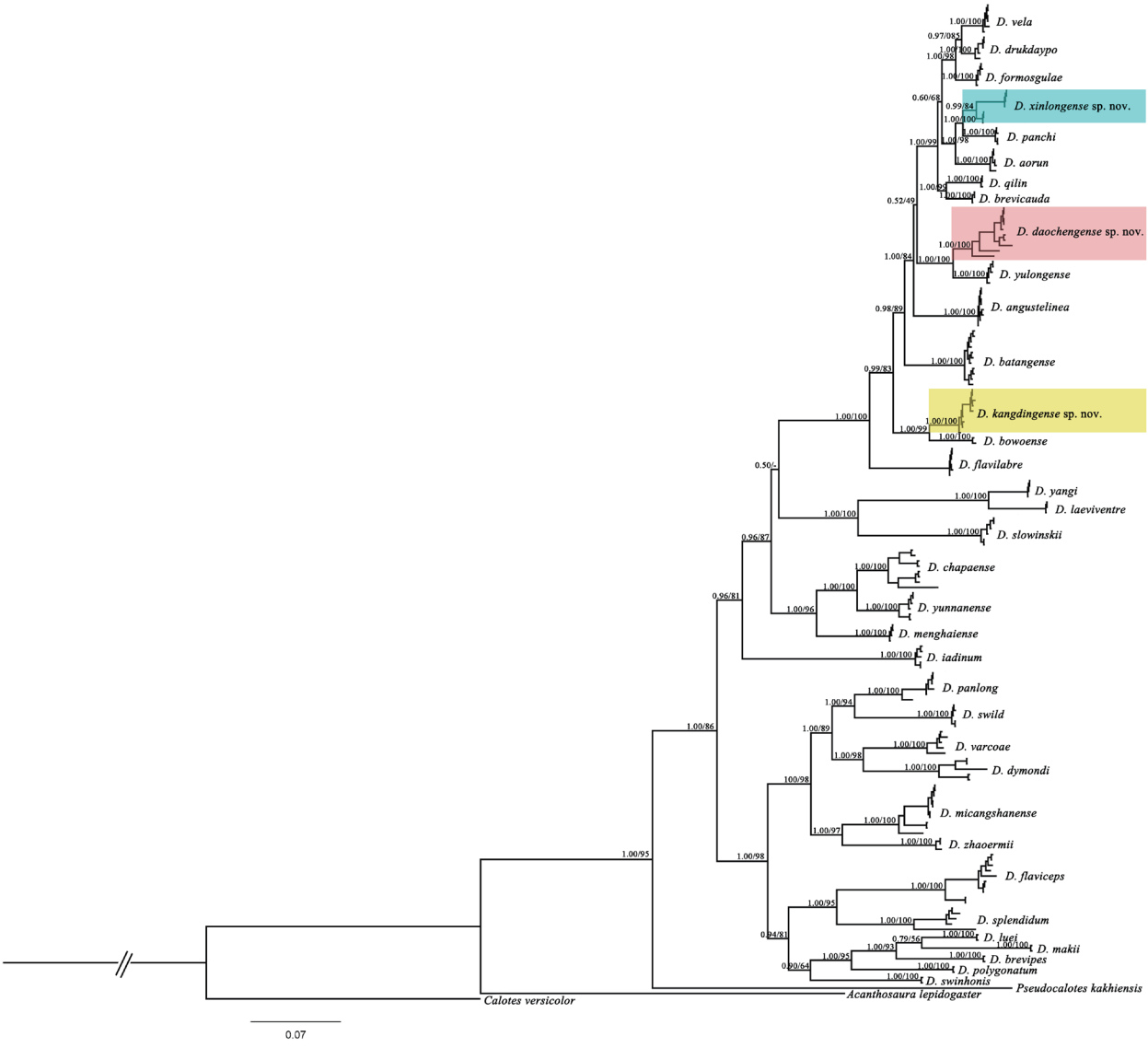

Figure 2 Phylogenetic tree of the genus *Diploderma* inferred from the mitochondrial *ND2*, Bayesian posterior probability/ML bootstrap support was denoted above node.

specific level.

3.2. Morphological analyses Based on their measurements, the Shuiluo River and Muli River valleys population, the upper-middle valley of the Yalong River population, and the Yalong River middle valley and Liqiu River valley population have their own unique morphological characteristics (Figure 3, Table 3). These three populations showed different morphological characteristics from nearby species (Table 4), similar to the results of molecular phylogenetic analyses above.

The upper-middle valleys of the Yalong River population has longer tail (TAL/SVL 206.8%–251.6% [average 226.8%] in males, and 169.5%–208.5% [average 189.7%] in females), T4S 14–18 (average 16) and F4S 20–25 (average 23), cyan or dark olive green gular spots present in both sexes in life, fourth toe with claw reaching eye when hindlimbs adpressed forward. It can be differentiated from nearby species *D. yulongense* by a suite of morphological characters, especially gular coloration and ornamentation in both sexes: light yellow or white ventrolateral body versus pale green to chartreuse in males; white to grey or light yellow spots present on each side of ventrolateral versus pale greenish yellow and chartreuse, and cyan or dark olive green to yellow gular spots present versus chartreuse to opaline green in both sexes in life.

The upper-middle valleys of the Yalong River population has shorter tails (TAL/SVL 146.7%–152.1% (average 149.4%) in males, and 144.8%–146.6% (average 145.9%) in females); T4S 16–21

Table 2 Uncorrected genetic distances of the sampled *ND2* coding region (1032bp) among the three new lineages (new species) and other species within the sub-clade I in the genus *Diploderma* (Figure 2).

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	*D. vela*																	
2	*D. drukdaypo*	0.025																
3	*D. formosgulae*	0.033	0.031															
4	***D. xinlongense* sp. nov.**	0.055	0.049	0.054														
5	*D. panchi*	0.057	0.05	0.047	0.043													
6	*D. aorun*	0.053	0.051	0.054	0.05	0.05												
7	*D. qilin*	0.047	0.05	0.049	0.057	0.059	0.059											
8	*D. brevicauda*	0.05	0.043	0.046	0.048	0.053	0.054	0.041										
9	***D. daochengense* sp. nov.**	0.08	0.081	0.079	0.091	0.092	0.09	0.08	0.084									
10	*D. yulongense*	0.078	0.077	0.076	0.087	0.09	0.08	0.075	0.079	0.034								
11	*D. angustelinea*	0.073	0.07	0.069	0.075	0.078	0.084	0.071	0.069	0.083	0.079							
12	*D. batangense*	0.072	0.079	0.078	0.082	0.077	0.083	0.079	0.08	0.081	0.081	0.084						
13	***D. kangdingense* sp. nov.**	0.078	0.082	0.08	0.082	0.091	0.085	0.077	0.076	0.101	0.092	0.093	0.085					
14	*D. bowoense*	0.093	0.094	0.094	0.089	0.097	0.095	0.09	0.089	0.105	0.102	0.092	0.089	0.055				
15	*D. flavilabre*	0.097	0.095	0.095	0.1	0.103	0.109	0.096	0.093	0.105	0.101	0.1	0.094	0.102	0.1			
16	*D. yangi*	0.169	0.171	0.177	0.178	0.18	0.183	0.171	0.167	0.195	0.185	0.177	0.177	0.186	0.196	0.188		
17	*D. laeviventre*	0.165	0.168	0.169	0.179	0.177	0.184	0.171	0.166	0.184	0.179	0.18	0.167	0.179	0.193	0.184	0.063	
18	*D. slowinskii*	0.162	0.164	0.165	0.164	0.168	0.173	0.172	0.161	0.178	0.169	0.176	0.162	0.168	0.182	0.173	0.149	0.159

(average 19) and F4S 13–16 (average 14); radial stripes below eyes present; gular spot always cyan surrounded by yellow in live males, and cyan or light cyan surrounded by white in live females. It can be differentiated from nearby species of *D. panchi* by a suite of morphological characters: T4S 16–21 (average 19) versus 20–24 (average 22); gular spot cyan versus distinct gular spots absent but mosaic light sulphur yellow patterns present in females.

The Yalong River middle valley and Liqiu River valley populations have longer tails (TAL/SVL 204.8%–227.1% [average 213.2%] in males, and 156.1%–192.5% [average 181.2%] in females); T4S 20–25 (average 23) and F4S 16–20 (average 17); radial stripes below eyes absent; ventrolateral body coloration yellow to light yellow, with yellow or white spots in males, light grey to white smoke with white or wheat spots in females. It can be differentiated from nearby species of *D. bowoense* by a suite of morphological characters: longer trunk length in males (TRL ≥ 46.8% SVL versus ≤ 45.3%); ventrolateral body yellow to light yellow, with yellow or white spots in males versus light grey with white spots in males; yellow gular spot present in males versus light chrome orange gular spots present in males and dark spectrum yellow in females.

Both the molecular phylogenetic relationships and the uncorrected pairwise distance inferred from *ND2*, and the integration of the differences from morphological data, suggest that the three new lineages from the three populations collected from the aforementioned localities represent three new species, they are described here.

3.3. Taxonomic accounts

3.3.1. *Diploderma daochengense* sp. nov. (Tables 3–4; Figure 3)

Chresonyms *Japalura flaviceps* Zhao *et al.*, 1999: 111–115 in part.; *Diploderma yulongense* Shu *et al.*, 2021: 259–264.

Suggested English name: Daocheng Mountain Lizard

Suggested Chinese name: 稻城攀蜥 (dào chéng pān xī)

Holotype Adult male, CIB119352 (filed number DC001), collected from Eyatong Township (28.04754478°N, 100.3224385°E; at elevation 1916 m a.s.l.), Daocheng County, Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China, collected by Huaming ZHOU and Jing LI on September 2021.

Allotype Adult female, CIB119353 (filed number DC003), also collected from Eyatong Ethnic Township (28.0469772°N, 100.32392371°E; at elevation 1930 m a.s.l.), and the same collecting information as the holotype.

Other specimens (Pratypes) The specimen DC004 (♀, 28.04838729°N, 100.3217799°E; at elevation 1925 m a.s.l.) collected from Eyatong Ethnic Township. The specimens 20210904 (♀, 27.946867°N, 100.435083°E; at elevation 1664 m a.s.l.), 20210905 (♂, 27.953308°N, 100.427531°E; at elevation 1652 m a.s.l.) collected from Eya Naxi Ethnic Township, Muli Tibetan Autonomous County, Liangshan Yi Autonomous Prefecture, Sichuan Province, China, by Huaming ZHOU and Jing LI on September 2021; 2019ML0037 (♂) and 2019ML0038 (♀) collected from Xiamaidi Township, Muli Tibetan Autonomous

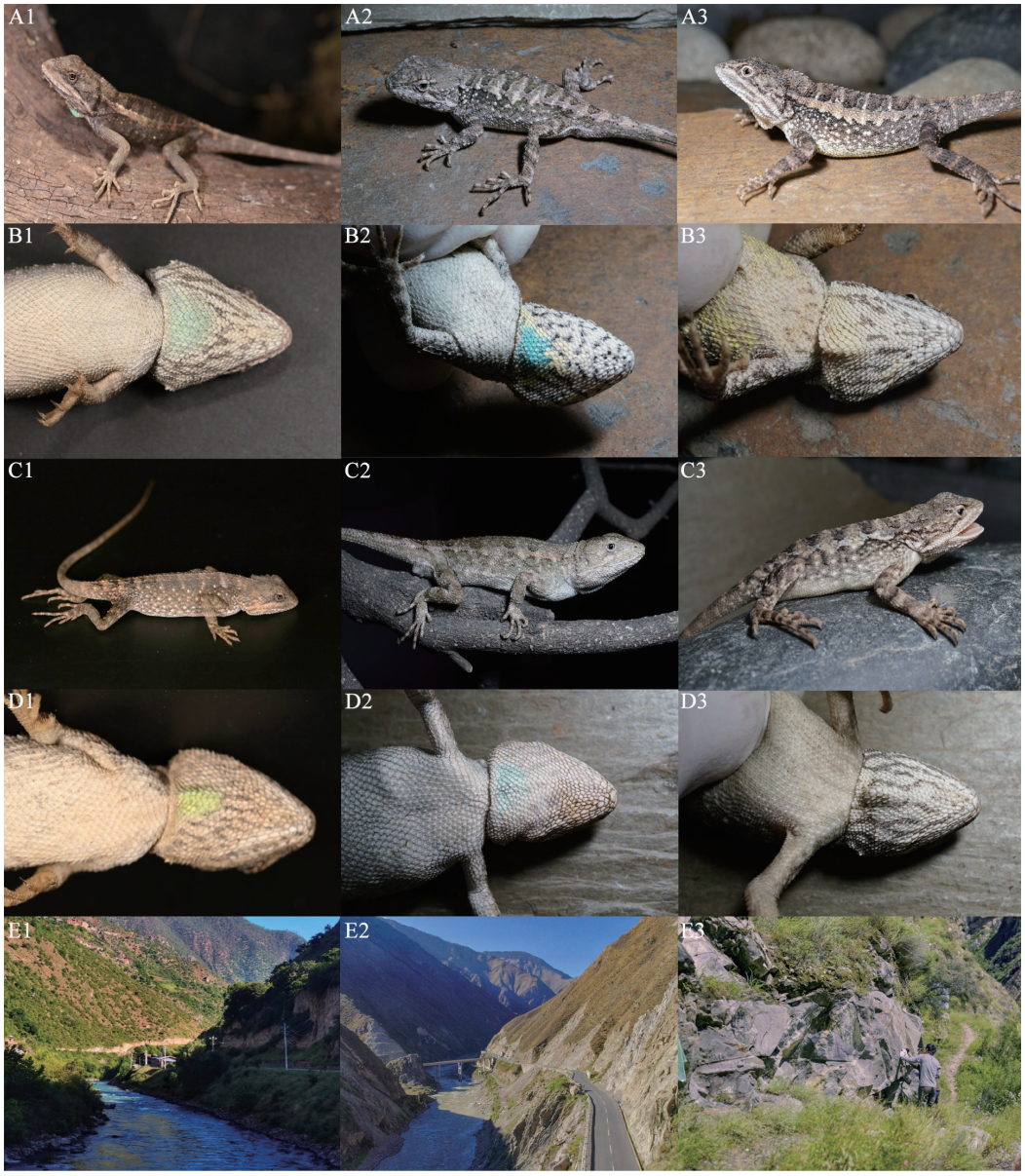

Figure 3 Display of the three new species and their habitats. 1: *Diploderma daochengense* **sp. nov.**, 2: *D. xinlongense* **sp. nov.**, 3. *D. kangdingense* **sp. nov.**; A: dorsolateral overview of holotype, B: ventral head view of holotype, C: dorsolateral overview of allotype, D: ventral head view of allotype; E: habitats (A1, B1, C1 and D1 photographed by Bo CAI; A2, B2, C2, D2, A3, B3, C3 and D3 by Meihua ZHANG and Jianping JIANG; E1, E2 and E3 by Huaming ZHOU).

County (27.789794°N, 101.200958°E; at elevation 1889 m a.s.l.) by Feng XIE, Puyang ZHENG and Mingyang CHENG on August 2019; 2019ML0006 (subadult, 28.283388°N, 100.661666°E; at elevation 2208 m a.s.l.) and 2019ML0012 (subadult, 28.287653°N, 100.654886°E; at elevation 2158 m a.s.l.) collected from Shuiluo Township, Muli Tibetan Autonomous County by Feng XIE, Puyang ZHENG and Mingyang CHENG on August 2019; ML070706 (♀, 28.287653°N, 100.654886°E; at elevation 2158 m a.s.l.) and ML070807 (♀, 28.290626°N, 100.666664°E; at elevation 2180 m a.s.l.) respectively collected from Shuiluo Township by Feng XIE, Puyang ZHENG and Mingyang CHENG on July 2020.

Etymology The specific epithet of "Daocheng" refers to a county name of Sichuan, and the new species is found on its southeastern edge.

Diagnosis *Diploderma daochengense* **sp. nov.** can be distinguished from other *Diploderma* species by the following characters: 1) TAL/SVL 206.8%–251.6% (average 226.8%) in males, and 169.5%–208.5% (average 189.7%) in females; 2) TRL/SVL 40.8%–67.3% in males and 45.6%–70.3% in females; 3) SEL/

Table 3 Morphological comparisons among the three new lineages (new species) in the genus *Diploderma*.

Species	***D. daochengense* sp. nov.**		***D. xinlongense* sp. nov.**		***D. kangdingensis* sp. nov.**	
Sex	♂	♀	♂	♀	♂	♀
Sample Size	3	6	3	3	4	5
SVL	57.5–59.0	53.89–66	4.4–4.8	5.4–5.8	54–62	5.3–6.2
TAL/SVL (%)	206.8–251.6	169.5–208.5	146.7–152.1	144.8–146.6	204.8–227.1	156.1–192.5
SEL/HL (%)	39.6–71.2	37.5–68.8	39.1–43.6	39.1–41.8	39.1–42.3	38.3–40.3
TRL/SVL (%)	40.8–67.3	45.6–70.3	43.3–45.1	45.3–52.6	46.8–48.6	50.1–56.8
HL/SVL (%)	30.2–31.8	28.2–32.7	31.2–31.8	29.4–32.7	30.5–32.4	28.7–31.2
FLL/SVL (%)	40.3–54.4	40.0–55.4	39.5–42.3	39.9–50.4	46.1–48.5	41.9–45.7
SDS	upper edge is smooth, no bright color transverse stripes	upper edge is smooth, no bright color transverse stripes	strongly jagged	strongly jagged	strongly jagged	strongly jagged
CDS	yellow (255 255 0, normally) or brown (165 42 42, dimly lit or stressed)	white to grey (190 190 190) or light yellow (255 255 224)	yellow	sandy brown (244 164 96), yellow or light grey (211 211 211, dimly lit or stressed)	yellow or sandy brown (dimly lit or stressed)	front yellow, rear grey or sandy brown
VLBC	white to grey or light yellow	white to grey	smoky white (245 245 245)	smoky white	yellow to light yellow	light grey to smoky white
SCVB	yellow, cyan (0 255 255) or white	yellow, cyan or white	light yellow and white	light yellow, white or wheat (245 222 179)	yellow or white	white or wheat
VBC	white or antique white (255 239 219, dimly lit or stressed)	white or antique white (dimly lit or stressed)	smoky white to white	smoky white to white	smoky white	smoky white
SFDC	present	absent	absent	absent	present	absent
SFNC	present	absent	absent	absent	absent	absent
NC	crest scale strongly erected	crest scale not strongly erected	crest scale not strongly erected	crest scale not strongly erected	crest scale strongly erected	crest scale not strongly erected
GP	present	present	present	present	present	present
GS	present	present	present	present	present	absent
GSC	cyan or dark olive green (202 255 112)	cyan or dark olive green	cyan surrounded by yellow	cyan or light cyan surrounded by white	yellow	same as around's color
HAF	reaching eye, few acrossing the eye	reaching eye, few postocular	reaching tympanum, not postocular	reaching tympanum, not postocular	reaching eye	reaching eye, few postocular

HL 39.6%–71.2% in males and 37.5%–68.8% in females; 4) T4S 14–18 (average 16) and F4S 20–25 (average 23); 5) no bright transverse stripes or bands on dorsal body; 6) ventral scales distinctively keeled; 7) tympanum concealed; 8) transverse gular fold deep, forming a distinct pouch across throat; 9) no radial stripes around eyes; 10) inner-lip coloration smoky white, and coloration of tongue and oral cavity light flesh color; 11) ventrolateral body white to grey or light yellow with yellow, cyan or white spots in males; 12) cyan or dark olive green gular spots present in both sexes in life; 13) upper edge of the dorsolateral stripes smooth, and yellow (normally), brown (when dimly lit or stressed) in males, gray while white or light yellow in females in life; 14) fourth toe with claw reaching eye when hindlimbs adpressed forward; 15) well-developed skin folds under nuchal crest present in males only, vertebral crest discontinuous between nuchal and dorsal sections with a distinct gap.

Description of holotype Adult male, body medium in size, SVL 57.6 mm; tail long, TAL 144.9 mm; head longer (18.3 mm) than width 12.6 mm; head depth 10.1 mm; snout-eye length 7.3 mm; foreleg length 23.2 mm; hindleg length 42.3 mm; toe IV length 12.1mm; trunk length 27.8 mm; TAL/SVL 251.6%; FLL/SVL 40.3%; HLL/SVL 73.4%; TRL/SVL 48.2%; SEL/HL 39.6%; HL/SVL 31.8%.

It has 10/8 supralabial scales, 10/11 infralabial scales, and 40 middorsal crest scales; finger IV subdigital lamellae 16/16; toe IV subdigital lamellae 24/22; nasal-supralabial scale rows 2/2; suborbital scale rows 3/3; eight stripes around the eye except the subocular regions, including one enlarged stripe extending from the posterior edge of the orbit to the corner of the mouth.

Table 4 Morphological characters of the three lineages (new species), their sister species and morphologically similar species.

Species	***D. daochengense* sp. nov.**	***D. xinlongense* sp. nov.**	***D. kangdingense* sp. nov.**	*D. yulongense*	*D. panchi*	*D. aorun*	*D. brevicauda*	*D. bowoense*	*D. qilin*
References	This study	This study	This study	Manthey *et al.*, 2012; Wang *et al.*, 2017	Wang *et al.*, 2020	Wang *et al.*, 2020	Manthey *et al.*, 2012; Wang *et al.*, 2021	Wang *et al.*, 2021	Wang *et al.*, 2020
Sample Size	11	7	10	15	4	11	7	4	13
SL	8–11 (9)	7–11 (8)	8–10 (9)	8–10 (9)	8–9 (8)	7–11 (9)	6–9 (8)	8–10 (9)	8–10 (9)
IL	8–13 (10)	9–13 (10)	9–12 (10)	7–11 (8)	9–11 (10)	9–13 (10)	7–11 (9)	9–12 (10)	8–13 (10)
SOR	3–4 (4)	2–3 (3)	3–4 (4)	3–5 (4)	4–5 (5)	3–5 (4)	3–4 (3)	3–4 (4)	3–5 (4)
MD	37–49 (41)	36–41 (38)	34–45 (40)	38–44 (40)	42–46 (45)	35–46 (40)	34–43 (39)	40–44 (42)	38–45 (41)
F4S	14–18 (16)	13–16 (14)	16–20 (17)	15–19 (17)	14–17 (15)	12–18 (15)	14–17 (16)	14–17 (15)	15–19 (17)
T4S	20–25 (23)	16–21 (19)	20–25 (23)	21–26 (24)	20–24 (22)	16–24 (21)	16–23 (20)	18–21 (20)	21–25 (22)
ILC	smoky white	smoky white	smoky white	smoky white	smoky white	smoky white	sulphur yellow	light flesh color	smoky white
CO	light flesh color	light flesh color	light flesh color	light flesh color	light flesh color	light flesh color	light flesh color	light flesh color	light flesh color
CTG	light flesh color	light flesh color	light flesh color	light flesh color	light flesh color	light flesh color	light orange yellow	light flesh color	light flesh color
VSS	strongly keeled	strongly keeled	strongly keeled	strongly keeled	strongly keeled	strongly keeled	strongly keeled	strongly keeled	strongly keeled
TS	concealed	concealed	concealed	concealed	concealed	concealed	concealed	concealed	concealed
SOC	white	radial stripes	white	white	radial stripes	radial stripes	white	white	radial stripes
CSL	smoky white	radial stripes	smoky white	smoky white	radial stripes	radial stripes	smoky white	black spots	radial stripes
RSBE	absent	present	absent	absent	present	present	absent	absent	present
GF	present	present	present	present	present	present	present	present	present

Transverse gular fold present, distinct; gular pouch present and distinct in life; gular spot present and grey lines on gular region; tympanum covered with scales; well-developed skin fold under nuchal crest present, vertebral crest discontinuous between nuchal and dorsal sections with gap; scales of ventral, head and body distinctively keeled; the fourth toe with claw reaching the eye not beyond it when hindlimbs adpressed forward. The lower edges of the dorsal stripes strongly serrated; the upper edge is smooth.

Coloration of holotype The background of the dorsal and lateral surfaces of the head is iron grey; two dorsal head stripes present above the eyes; subocular and supralabial are smoky white, the middle area is a light grey horizontal short stripes; infralabial is white. Inner-lip is smoky white, oral cavity and tongue are light flesh color. Gular region has cyan gular spot and grey lines; nasal is consistent with surrounding as light grey. Seven dorsal patches present, iron grey; of dorsolateral stripes is yellow (normally), brown (dimly lit or stressed); ventrolateral body is grey with white spots; ventral body is white (normally), antique white with light grey reticulates (dimly lit or stressed); interfemoral color is the same as ventral body in life.

Comparisons *Diploderma daochengense* **sp. nov.** is the sister species of *D. yulongense*, they are morphologically similar, but has different characters, such as the following: 1) SEL/HL 39.6%–71.2% versus 36.8%–39.0% in males, and 37.5%–68.8% versus 36.7%–38.2% in females; 2) the upper edge of the dorsolateral stripes smooth versus strongly jagged in males; 3) ventrolateral body light yellow or white versus pale green to chartreuse in males; 4) white to grey or light yellow spots present on each side of ventrolateral versus pale greenish yellow and chartreuse, and 5) gular spots cyan or dark olive green to yellow versus chartreuse to opaline green in both sexes in life.

The new species differs from other congeners of the genus *Diploderma* as follows: differs from *D. fasciatum and D. zszechwanensis* by having the following combination of characters: 1) slightly square green patches non-existent on mid dorsum, 2) males having dorsolateral stripes and dorsolateral series of spots; differs from *D. varcoae*, *D. swild*, *D. slowinskii*, *D. panlong* and *D. dymondi* by having concealed tympanum (Wang *et al*., 2020); differs from *D. grahami*, *D. micangshanense*, *D. yunnanense*, *D. chapaense*, *D. swinhonis*, *D. makii*, *D. luei*, *D. brevipes*, *D. polygonatum*, *D. ngoclinense*, *D. splendidum*, *D. hamptoni* and *D. menghaiense* by having deep transverse gular fold and forming a distinct pouch across throat; differs from *D. yangi*, *D. panlong*, *D. dymondi*, *D. swild*, *D. angustelinea* and *D. iadinum* by having a dorsolateral stripe shape strongly jagged versus smooth or feebly jagged; differs from *D. laeviventre* and *D. drukdaypo* by having distinctively keeled ventral scales; differs from *D. drukdaypo*, *D. flaviceps*, *D. vela*, *D. panchi* and *D. kangdingense* **sp. nov.** by having gular spots in both sexes; differs from *D.brevicauda* by having: 1) inner-lip smoky white versus sulphur yellow; 2) the tongue light flesh versus light orange yellow; differs from *D. aorun*, *D. qilin*, *D. flavilabre*, *D. zhaoermii*, *D. batangense*, *D. formosgulae*, *D. bowoense*, *D.brevicauda*, *D. angustelinea*, *D. kangdingense* **sp. nov.** and *D. xinlongense* **sp. nov.** by having white to grey or light yellow ventrolateral body in live males, dark olive green or cyan gular spots in both sexes, and no dark radial stripes around eyes.

Distribution At present, the new species is only known to be distributed in 4 locations in Sichuan Province, China: Eyatong Township in Daocheng County, Sichuan Province; Eya Naxi Ethnic Township, Xiamaidi Township and Shuiluo Township in Muli Tibetan Autonomous County. The area between the distribution points exceeds 2300 km^2 and the farthest straight-line distance between known distribution points is approximately 91 km. The known altitude range of this species is 1652–2608 m. This new species inhabits the deciduous broad-leaved forest along the Shuiluo River and Muli River and is active at the edge of forests, in bushes, and sometimes even on roads.

3.3.2. *Diploderma xinlongense* sp. nov. (Tables 3–4; Figure 3)

Suggested English name: Xinlong Mountain Lizard

Suggested Chinese name: 新龙攀蜥 (xīn lóng pān xī)

Holotype Adult male, CIB119354 (filed number 20210907), collected from Eri village (30.8954°N, 100.231797°E; at elevation 3040 m a.s.l.), Wuya Township, Xinlong County, Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China, collected by Huaming ZHOU and Jing LI on September 2021.

Allotype Adult female, CIB119355 (filed number 20210906), also collected from Eri vallige (30.895089°N, 100.230106°E; at elevation 3057 m a.s.l.), Wuya Township, Xinlong County, Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China, by Huaming ZHOU and Jing LI.

Etymology The specific epithet of "Xinlong" refers to the Xinlong County where the new species was discovered.

Other specimens (Paratypes) The specimens 20210908 share the same locality as the holotype, the 20210909 (♀, 30.525361°N, 100.339067°E; at elevation 2961 m a.s.l.), 20210910 (subadult, 30.526836°N, 100.337386°E; at elevation 2976 m a.s.l.), and 20210911(♂, 30.528414°N, 100.3357°E; at elevation 2951 m a.s.l.) were collected from Junba Brindge, Xinlong County; 20210912 (♂, 30.895036°N, 100.228056°E; at elevation 3052 m a.s.l.) collected from Wuya Township, Xinlong County. All the specimens were from Xinlong County, Ganzi Tibetan Autonomous Prefecture, China, and the collector information as the holotype.

Diagnosis *Diploderma xinlongense* **sp. nov.** can be mainly distinguished from other *Diploderma* species by the following characters: 1) TAL/SVL 146.7%–152.1% (average 149.4%) in males, and 144.8%–146.6% (average 145.9%) in females; 2) TRL/

SVL 43.4%–45.1% in males and 45.3%–52.6% in females; 3) HL/SVL 31.2%–31.8% in males and 29.4%–34.2% in females; 4) T4S 16–21 (average 19) and F4S 13–16 (average 14); 5) ventral scales distinctively keeled; 6) tympanum concealed; 7) transverse gular fold deep, forming a pouch across throat; 8) radial stripes below eyes present; 9) ventrolateral body smoky white to white (one specimen is mosaic light yellow), with light yellow and white spots in males, light grey white or wheat spots in females; 10) gular spot always cyan surrounded by yellow in live males while cyan or light cyan surrounded by white in live females; 11) inner-lip smoky white, and tongue and oral cavity light flesh color; 12) dorsolateral stripes strongly jagged, and yellow in males while sandy brown (normally) or light grey (dimly lit or stressed) in live females; 13) skin fold under dorsal crest and nuchal crest are weak; 14) fourth toe with claw reaching tympanum when hindlimbs adpressed forward.

Description of holotype Adult male, body small in size, SVL 45 mm; tail short, TAL 66 mm; head longer 1 (4.3 mm) than width 9.3 mm; head depth 6.6 mm; snout-eye length 5.6 mm; foreleg length 17.8 mm; hindleg length 29.0 mm; toe IV length 7.5 mm; trunk length 19.5 mm; TAL/SVL 146.7%; FLL/SVL 39.5%; HLL/SVL 64.4%; TRL/SVL 43.4%; SEL/HL 39.1%; HL/SVL 31.7%.

It has seven supralabial scales on each side, 9/10 infralabial scales, and 38 middorsal crest scales; finger IV subdigital lamellae 14 on each side; toe IV subdigital lamellae 16/17; nasal-supralabial scale rows 1/1; suborbital scale rows 3/3; more than eleven radiated black stripes around the eye, including one enlarged stripe extending from the posterior edge of orbit to the corner of mouth and the anterior edge of tympanic; dorsal head has three stripes; transverse gular fold present, distinct; gular pouch present in life, but indistinct after preservation; gular spot present and dark, short lines on gular region; tympanum covered with scales; skin fold under nuchal crest absent; nuchal crest absent; skin fold under dorsal crest absent; scales of ventral, head and body distinctively keeled; the fourth toe with claw reaching the tympanum not to the jaw joint when hindlimbs adpressed forward; the upper and lower edges of the dorsal stripes strongly serrated.

Coloration of holotype The background of the dorsal and lateral surfaces of the head is medium grey; dorsal head having three dark grey stripes; inner-lip is smoky white, oral cavity and tongue are light flesh color; gular spot color is cyan surrounded by yellow in life; nasal coloration is consistent with surrounding as light grey; dorsal patches present, of which the shoulder and caudal base are independent patches, but on the central trunk are joined together. Dorsolateral stripes are yellow; ventrolateral body is white with light yellow spots; ventral body is white, in a dark or stressful environment, there will be a few scattered black spots; interfemoral is unobvious light cyan in life.

Comparisons *Diploderma xinlongense* **sp. nov.** is morphologically similar to *D. aorun*, but it has some features that can distinguish it from the latter: 1) skin fold under dorsal crest and nuchal crest in males weak versus strongly; 2) crest scale not strongly erected versus strongly in both sexes; 3) gular spot in males always cyan surrounded by yellow versus cyan surrounded by white; 4) TAL/SVL 146.7%–152.1% versus 212.0%–221.1% in males, and 144.8%–146.6% versus 191.4%–207.7% in females.

Diploderma xinlongense **sp. nov.** is the sister species of *D. panchi*, but it can be distinguished from it mainly by the following characters: 1) MD in females 36–41 (average 38) versus 42–46 (average 45); 2), T4S 16–21 (average 19) versus 20–24 (average 22); 3) HL/SVL is 29.4%–34.2% versus 27.0%–28.8% in females; 4) gular spot cyan versus distinct gular spots absent but mosaic light sulphur yellow patterns in females.

For other species, *Diploderma xinlongense* **sp. nov.** differs from *D. fasciatum and D. zszechwanensis* by having dorsolateral stripes and dorsolateral series of spots in males versus large, slightly square green patch on the mid-dorsum. It differs from *D. varcoae*, *D. swild*, *D. slowinskii*, *D. panlong*, *D. dymondi* by having concealed tympanum; differs from *D. grahami*, *D. micangshanense*, *D. yunnanense*, *D. chapaense*, *D. swinhonis*, *D. makii*, *D. luei*, *D. brevipes*, *D. polygonatum*, *D. ngoclinense*, *D. splendidum*, *D. hamptoni* and *D. menghaiense* by having a deep transverse gular fold; differs from *D. laeviventre* and *D. drukdaypo* by having distinctively keeled ventral scales; differs from *D. laeviventre*, *D. panlong*, *D. dymondi*, *D. swild*, *D. yangi*, *D. angustelinea* and *D. iadinum* by having a dorsolateral stripe shape strongly jagged versus smooth or feebly jagged; differs from *D. dymondi*, *D. micangshanense*, *D. slowinskii*, *D. swild*, *D. flaviceps*, *D. vela*, *D. drukdaypo*, *D.* varcoae, and *D.panlong* by having gular spots present in males, differs from *D. kangdingense* **sp. nov.**, *D. panchi* and *D. zhaoermii* by having gular spots in females; differs from *D. aorun*, *D. qilin*, *D. flavilabre*, *D. zhaoermii*, *D. batangense*, *D. formosgulae D. bowoense*, *D. bowoense*, *D. daochengense* **sp. nov.** and *D. kangdingense* **sp. nov.** by having always cyan gular spot surrounded by yellow in males while the cyan in females in life.

Distribution To date, the new species is only known to be distributed in the upper-middle Yalong River, from Eri Village to the area around the Junba Bridge in Xinlong County, Sichuan Province, China. The known altitude range of this species is 2950–3080 m, and the farthest straight-line distance between known distribution points is approximately 43 km. This new species inhabits the dry valley along the upper-middle Yalong River, and is active at the edge of coniferous forests, bushes or rock piles in the valley.

3.3.3. *Diploderma kangdingense* sp. nov. (Tables 3–4; Figure 3)

Chresonyms *Japalura flaviceps* Zhao *et al.*, 1999: 111–115 in part; Zhao, 2003: 84 in part; Cai *et al.*, 2018 in part.

Suggested English name: Kangding Mountain Lizard
Suggested Chinese name: 康定攀蜥 (kāng dìng pān xī)
Holotype Adult male, CIB119356 (filed number 20210917), collected from Pusharong Village (29.417275°N, 101.159856°E; at elevation 2409 m a.s.l.), Pusharong Township, Kangding City, Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China, collected by Huaming ZHOU and Jing LI on August, 2021.
Allotype Adult female, CIB119357 (filed number 20210916), also collected from Pusharong Village (29.417272°N, 101.165431°E; at elevation 2432m a.s.l.), Pusharong Township, Kangding City, Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China, collected by Huaming ZHOU and Jing LI on August, 2021.
Etymology Kangding City is the capital of Ganzi Tibetan Autonomous Prefecture, which is located in the east of Ganzi in Sichuan Province. The specific epithet refers to the Kangding City where the new species was discovered.
Other specimens (Paratypes) The specimens 20210913 (♀ , 29.420342 N, 101.144353 E; at elevation 2421 m a.s.l.), 20210914 (subadult, share the same locality as 20210913) and 20210915 (♀ , 29.419633 N, 101.143456 E; at elevation 2430m a.s.l.) were collected from Bosihe Town of Yajiang County by Huaming ZHOU and Jing LI on August, 2021; KD2021080101 (♂), KD2021080102 (♂) and KD2021080104 (♂), KD2021080103(♀), KD2021080105(♀) collected from Pusharong Village (29.419742 N, 101.153925 E; at elevation 2430 m a.s.l.), and the collecting information same as the holotype.
Diagnosis *Diploderma kangdingense* **sp. nov.** can be mainly distinguished from other *Diploderma* species by the following features: 1) TAL/SVL 204.8%–227.1% (average 213.2%) in males, and 156.1%–192.5% (average 181.2%) in females; 2) TRL/SVL 46.8%–48.6% in males and 50.1%–56.8% in females; 3) T4S 20–25 (average 23) and F4S 16–20 (average 17); 4) bright transverse stripes on dorsal body, especially in males in life; 5) ventral scales distinctively keeled; 6) tympanum concealed; 7) transverse gular fold deep in both sexes, and males having a distinct pouch across throat; 8) inner-lip smoky white, and tongue and oral cavity light flesh color; 9) dark stripe patterns on the ventral head; 10) gular spot present in males (yellow), and absent in females; 11) dorsolateral stripes strongly jagged, and yellow in males while front yellow, rear grey or sandy brown in females; 12) radial stripes below eyes absent; 13) ventrolateral body yellow to light yellow, with yellow or white spots in males, light grey to smoky white with white or wheat spots in females; 14) fourth toe with claw reaching eye when hindlimbs adpressed forward; 15) well-developed skin folds under nuchal crest present in males only, vertebral crest discontinuous between nuchal and dorsal sections with gap.
Description of holotype Adult male, body medium in size, SVL 54 mm; tail long, TAL 113 mm; head longer (17.5 mm) than width 11.7 mm, head depth 9.2 mm; snout-eye length 7.4 mm; foreleg length 25.3 mm; hindleg length 42.0 mm; toe IV length 10.81 mm; trunk length 25.25 mm; TAL/SVL 209.3%; FLL/SVL 46.9%; HLL/SVL 77.8%; TRL/SVL 46.8%; SEL/HL 42.3%; HL/SVL 32.4%.

It has 8/9 supralabial scales, 9/10 infralabial scales, and 35 middorsal crest scales; finger IV subdigital lamellae 20/18; toe IV subdigital lamellae 25/25; nasal-supralabials scale rows 1/1; suborbital scale rows 3/3; three stripes around the eye except the subocular regions, including one enlarged stripe extending from the posterior edge of orbit to the corner of mouth and the anterior edge of tympanic, one stripes extended from the postsub-orbit to the occiput, and one stripes extended from the preocular to nasal. Transverse gular fold present, distinct; gular pouch present and distinct in life; gular spot present and grey lines on gular region; tympanum covered with scales; skin fold under nuchal crest absent; nuchal crest present; skin fold under dorsal crest present; scales of ventral, head and body distinctively keeled; fourth toe with claw reaching eye not beyond it when hindlimbs adpressed forward; the upper and lower edges of the dorsal stripes strongly serrated; the lower edge stronger.
Coloration of holotype The background of the dorsal and lateral surfaces of the head is seal brown; dorsal head stripes are unobvious; subocular and supralabial are smoky white, the middle area is a light grey horizontal short stripe; infralabial is white. Inner-lip is smoky white, and the oral cavity and tongue are light flesh color. Gular region has yellow spots and grey lines; nasal coloration is consistent with surrounding smoky white. Dorsal patches present, but connected and corrugated; dorsolateral stripes is yellow (normally), brown (dimly lit or stressed); ventrolateral body is yellow with white spots; ventral body is white, and light grey reticulates appear in low light or stressed state; interfemoral color is the same as ventral body in life.
Comparisons *Diploderma kangdingense* **sp. nov.** is morphologically similar to *D. qilin*, but it has some features that can be distinguished from the latter: 1) presence of dark stripe patterns on the ventral head versus grey reticulated patterns; 2) gular having yellow spot in males versus gular having light sulphur yellow spots in both sexes; 3) dorsolateral stripes yellow and sandy brown in males, yellow and grey in females versus cream yellow in males, beige in females; 4) radial stripes below eyes are absent versus present.

Diploderma kangdingense **sp. nov.** is the sister species of *D. bowoense*, but it can be distinguished from it by the following characters: 1) longer trunk length in males (TRL ≥ 46.8% SVL versus ≤ 45.3%); 2) more T4S 20–25 (average 23) versus 18–21 (average 20); 3) more F4S 16–20 (average 17) versus 14–17

(average 15); 4) ventrolateral body yellow to light yellow, with yellow or white spots in males versus light grey with white spots in males; 5) gular having yellow spot in males versus gular having light chrome orange spots present in males and dark spectrum yellow spots in females; 6) dorsolateral stripes yellow and sandy brown in males, yellow and grey in females versus cream in males, sulphur yellow in females.

For other species, *Diploderma kangdingense* **sp. nov.** differs from *D. fasciatum and D. zszechwanensis* by having dorsolateral stripes and dorsolateral series of spots in males versus large, slightly square green patch on the mid-dorsum. It differs from *D. varcoae*, *D. swild*, *D. slowinskii*, *D. panlong*, and *D. dymondi* by having concealed tympanum; differs from *D. grahami*, *D. micangshanense*, *D. yunnanense*, *D. chapaense*, *D. swinhonis*, *D. makii*, *D. luei*, *D. brevipes*, *D. polygonatum*, *D. ngoclinense*, *D. splendidum*, *D. hamptoni* and *D. menghaiense* by having deep transverse gular fold and forming a distinct pouch across throat; differs from *D. laeviventre* and *D. drukdaypo* by having distinctively keeled ventral scales; differs from *D. laeviventre*, *D. panlong*, *D. dymondi*, *D. swild*, *D. yangi*, *D. angustelinea* and *D. iadinum* by having a dorsolateral stripe shape strongly jagged versus smooth or feebly jagged; differs from *D. panlong*, *D.* swild, *D. micangshanense*, *D. slowinskii*, *D. swild*, *D. flaviceps*, *D. vela*, and *D. drukdaypo* by having gular spots in males; differs from *D. panchi* by having no typical radial stripes below eyes, no light sulphur yellow mosaic gular pattern; longer tail length (in females TAL ≥ 156.1% SVL versus ≤ 151.5%.); differs from *D.brevicauda* by having 1) inner-lip smoky white versus sulphur yellow; 2) the tongue light flesh color versus light orange yellow; and differs from *D. daochengense* **sp. nov.,** *D. xinlongense* **sp. nov**., *D. menghaiense*, *D.yangi*, *D. aorun*, *D. batangense*, *D. angustelinea*, *D. qilin*, *D. iadinum*, *D. laeviventre*, *D.flavilabre*, and *D. yulongense* by having gular spots absent in females; differs from *D. aorun*, *D. qilin*, *D. flavilabre*, *D. zhaoermii*, *D. batangense*, *D. formosgulae* and *D. bowoense* by having yellow ventrolateral and yellow gular spots present in live males, and no dark radial stripes around eyes in both sexes.

Distribution At present, the new species is only known from the type locality near the middle Yalong River and Liqiu River, a tributary of the Yalong River, in Sichuan Province, China. The known altitude range of this species is 2409–2432 m. This new species inhabits the warm-dry valley along the middle Yalong River and active at the edge of coniferous and broad-leaved forest, in bushes or on rock piles in the valley.

4. Discussion

In terms of morphology, the differences between these three new species and other *Diploderma* species are mainly reflected in the characters: shape and color of dorsolateral stripe, gular spot coloration, radial stripe state below eyes, ventrolateral body and ventral coloration, nuchal crest state (Wang *et al*., 2020), and the reaching area of hindlimbs adpressed forward (Zhao *et al*., 1999). Coloration patterns and ornamentation in reptiles have taxonomic significance (Wang *et al*., 2020), especially in the family Agamidae. Our findings further confirm this view. At present, there are a variety of color models to describe color with different color names and parameters. By focusing on the most widely used color model internationally, taxonomic researchers would benefit comparative and interdisciplinary research. The RGB (red, green, blue) color model is a three-channel default mode that has a range of approximately16.78 million colors. It is widely used in various fields, especially in scanning and image processing (Ibraheem *et al*., 2012), and in spectrophotometers. The RGB colors are easy to query on the computer, and to obtain RGB color cards, and RGB colors easily convert to other color systems. Therefore, we attempted to use this model here.

However, we found that reptile color changes in response to changes in ambient temperature or possibly even stress. Specifically, reptile colors will also vary due to light intensity, audience visual difference, and the parameter setting of the photographs. Therefore, it is hard to accurately describe the color of a species, and there are always some deviations in the color description. Meanwhile, the color of gular spot is not only one type in a species. The gular spot of *Diploderma daochengense* **sp. nov.** has two colors: Cyan or Dark Olive Green, and may appear in both males and females. Moreover, the gular spot contains more than one color in the same individual, such as, the gular spot of *Diploderma xinlongense* **sp. nov.** has two layers of color. Hence, more attention should be given to body color under different temperatures or illumination levels, and body color in the active range should be selected as the basis of species classification in practical studies. In the future, strengthening research on the color variation range of species may promote research on taxonomy and behavioral ecology.

In terms of phylogenetic relationship and geographical distribution, the three new species cluster together with species in the upper Lancang River, the middle and upper Jinsha River, and the middle and upper Yalong River formed the subclade I; the species in the middle and upper reaches of the Nujiang River formed the subclade II; the species in southwestern Yunnan (the lower of the Nujiang River, the lower Lancang River and the Yuanjiang River Valleys) formed the subclade III. The phylogenetic position of *D. iadinum*, with a relatively special distribution located in the middle reaches of the Lancang River, formed the subclade IV alone, as the base of the group of subclades I\II\III; those species distributed in the lower Yalong River-Lower Jinsha River, Minjiang River-Qinling Mountains, Dadu River-the middle reaches of the Yangtze River, Taiwan

island formed the subclade V, being the sister group to the that of the subclades I\II\III\IV. This distribution patterns is similar to that of Wang *et al.* (2020). These relationships indicate a strong correlation between phylogenetic relationships and geographic distribution of the genus *Diploderma*.

However, the internal phylogenetic relationship of the subclade I does not strictly correspond to the river valley. For example, *Diploderma xinlongense* **sp. nov.** and *D. panchi* in the middle reaches of the Yalong River are in the same branch with *D. aorun* in the middle and upper reaches of the Jinsha River; *D. daochengense* **sp. nov.** are distributed in two adjacent tributaries of the Jinsha River; *D. kangdingense* **sp. nov.** and *D. xinlongense* **sp. nov.** are distributed upstream of their respective sister species. To some extent, this reflects the complexity of the speciation processes of the Qinghai-Tibet Plateau on shaping their phylogenetic relationships and geographical distribution patterns, and reflects the important role of the Shaluli Mountains in the process of species differentiation of the *Diploderma*.

Recent studies continue to improve our understandings of the taxonomy and phylogeny of the Mountain Lizard genus *Diploderma* (Cai *et al.*, 2022; Wang *et al.*, 2022). The discoveries of these three new species in and around the Shaluli Mountains provide new insights into the diversity and the distribution patterns of the genus *Diploderma*, and verify the hypothesis that there might be additional hidden species within this genus in the Hengduan Mountain Region of China (Cai *et al.*, 2022; Wang *et al.*, 2022), further indicating that the Shaluli Mountains and vicinity are one of the regions with the highest concentration of the Mountain Lizard. The taxonomic discovery further highlights the underestimated diversity of the genus and the importance of habitat conservation of the neglected hot-dry valley ecosystems in the Hengduan Mountain Region of China, especially in the Jinsha River and Yalong River valleys.

Acknowledgements We thank Feirong JI, Ayi BUDIAN, Peng YAN, Hui LI, Guocheng SHU and Puyang ZHENG for their help in the laboratory work, thank Jiatang Li for his help in the Museum of Herpetology, Chengdu Institute of Biology (CIB). This work is supported by the Second Tibetan Plateau Scientific Expedition and Research Program (STEP 2019QZKK05010503 and 2019QZKK04020202), the Biodiversity Survey and Assessment Project of the Ministry of Ecology and Environment (2019HJ2096001006), and China Biodiversity Observation Networks (Sino BON); Survey of wild vertebrates in Ganzi Prefecture (20yyjs00030).

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Handling Editor: Heling Zhao

How to cite this article:

Cai B., Zhang M. H., Li J., Du S. M., Xie F., Hou M., Zhou H. M., Jiang J. P. Three New Species of *Diploderma* Hallowell, 1861 (Reptilia: Squamata: Agamidae) from the Shaluli Mountains in Western Sichuan, China. Asian Herpetol Res, 2022, 13(4): 205–223. DOI: 10.16373/j.cnki.ahr.220040

Appendix

Table S1 Morphological data of the type series of *Diploderma daochengense* **sp. nov.**, *D. xinlongense* **sp. nov.** and *D. kangdingense* **sp. nov.** All morphometric measurements are in the unit of mm. For measurement methods and abbreviations, see the Methods section. The file can be downloaded from the website https://pan.baidu.com/s/1zUzA48_qxYEj2bq_6Cjtag?pwd=2210 (access code: 2210).